Human Performance Data Project (HPDP) – Operational Data Repository for Future Spacecraft Design

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What is the Human Performance Data Project (HPDP)?

- The HPDP was created by NASA's Human Research Program (HRP) to define, identify, store, and make available for use data associated with human performance in human spaceflight or supporting ground operations.

- The HRP roadmap for funding research activities is based on identified risks associated with human spaceflight, and addressing those risks for filling knowledge gaps (referred to as HRP's risk and gap structure)

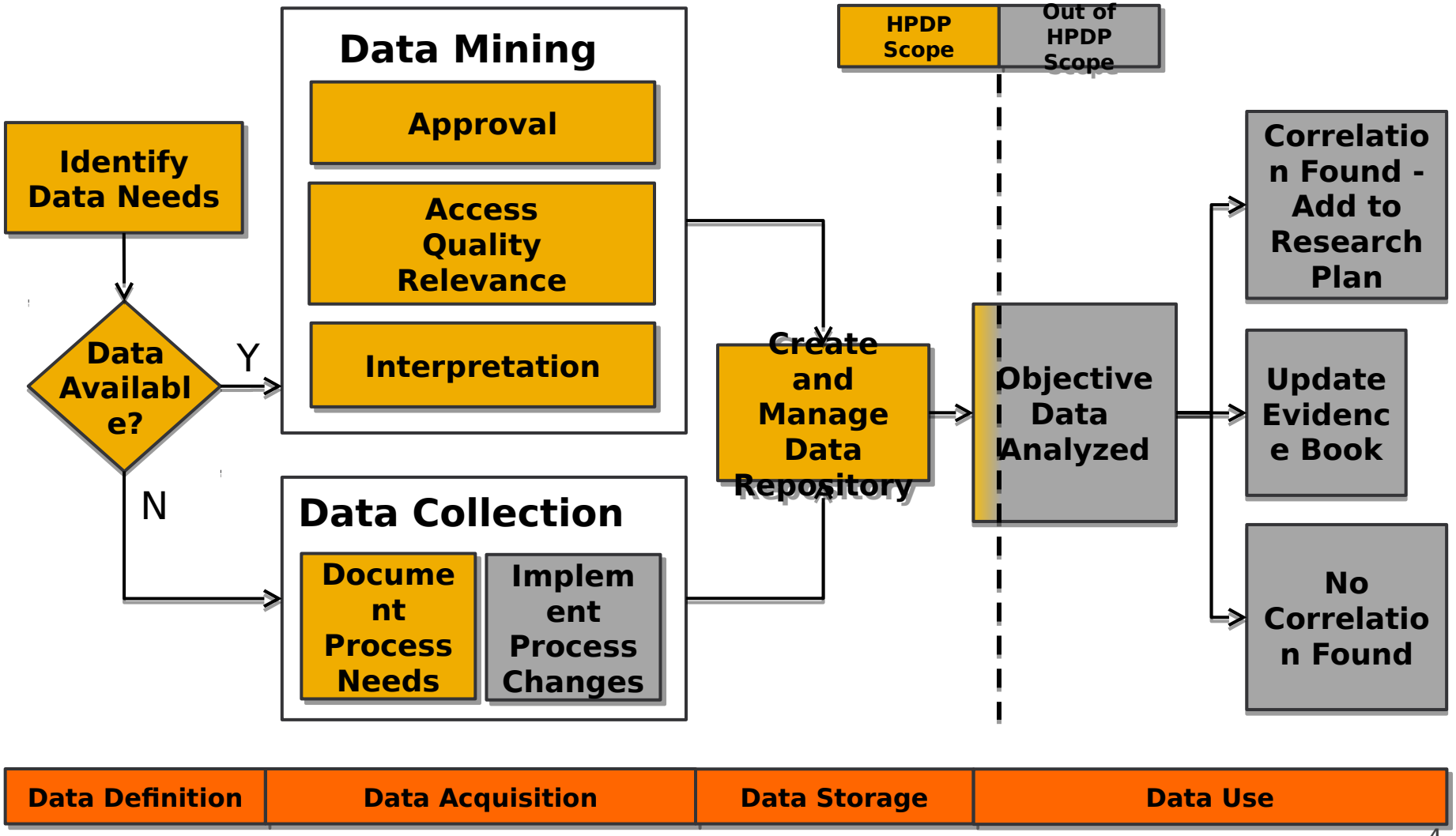
- We loosely define human performance as a person's level of success in completing a given task. Our efforts include the identification of factors that may shape or alter that performance, either positively or negatively

- Goals:
  - Inform and enhance operations to maximize crew time efficiency and

Why are we doing this?

- Human spaceflight is highly intensive:
  - Resources, costs, and risks
- Multiple factors converge on human performance:
  - Equipment, task design, training / skill level, fatigue and workload issues, communication, environmental factors, etc.
- Process improvement requires clear understanding of relative contributions of these and other factors
- Agency lacks comprehensive understanding of spaceflight human performance
- Few identified operational metrics

HPDP Scope and Work Process



Topics of Interest

- Identification of human performance metrics
- Data access
- Consent
- Data repository concerns:
  - Determination of need for System of Record (SOR) for human performance data and draft SOR Notice (SORN) under internal review
- Assess challenges and possible solutions by conducting a test case, approached from the standpoint of an internal or external PI:
  - *ISS Robotics*: Correlate medical and research data with changes in the performance of humans during on-orbit robotic tasks

Robotics Test Case: Recap

- **Hypothetical Research Question:**
  - Are certain variables related to medical or environmental conditions associated with deltas in the performance of humans during on-orbit tasks?
  - Specifically, is duration of sleep associated with performance deltas in robotic activities?
- **Retrospective Study Components:**
  1. Identify station timelines for robotics activity
  2. Obtain access to robotics related measures and outcomes.
  3. Initiate performance data download, analysis and interpretation.
  4. Obtain access to human factors, environmental, and medical parameters (both operational and research).
  5. Look for association between performance measures and HF, environmental, or medical parameters

Step 1: Identifying Robotics Activity

- There are several sources of information one can use to identify robotic activities on ISS:
  - Station Timelines
  - Mission Control Console Generated Logs (REMLOGs)
  - Flight Controller Logs (ROBO Logs)
  - Onboard Short Term Plan Viewer (OSTPV)
- Each has its use, though all were found to lack sufficient level of detail
  - This required cross-checking with multiple sources and types of data (e.g. timelines with telemetry)
- Challenges:
  - **The station timelines were publicly available but most of the others required personal contacts within the operations group and/or advanced access permission requests**

Step 1: Identify Robotics Activity
Station Timelines

Generated in advance, in Russian, then translated to English

Few details

Available online

Actuals are in OSTPV, requires ops access

Example:

GMT	Crew	Activity
08:30-10:00	FE-1	Cleaning ГЖТ4 (Gas-Liquid Heat Exchanger) BT-7 Fan Screen
08:45-10:00	FE-2	Physical Exercise (VELO)
09:50-10:00	CDR	**On MCC GO** Mate Telemetry Connectors to БИТС2-12
10:00-10:10	CDR	Cable 17КС42Ю8242А-9030, 9040 Installation. Close-out ops
10:00-11:15	FE-2	Physical Exercise (ARED)
10:05-10:15	FE-1	(TVIS) Weekly Maintenance with SLD Contingency Configuration
10:10-10:20	CDR	**On MCC GO** Monitoring Temperature of Secondary Purification Unit after Elektron Activation
10:15-11:15	FE-1	Physical Exercise (TVIS)
10:20-11:00	CDR	Cable 240ГК.42Ю5100А-570 Installation in DC1 (to support ЗПКС and ДПС1С telemetry monitoring)
11:00-11:30	CDR	Changeout of CPB-K2M purification column unit / ***New #802034 (00048357R, ФГБ1ПГО_4_408_1). Discard the Removed Unit. Update the IMS***
11:15-12:45	FE-1	Physical Exercise (ARED)
11:15-11:45	FE-2	DOUG Software Review
11:30-13:00	CDR	Physical Exercise (TVIS), day 2
11:45-12:45	FE-2	SSRMS Ops
12:45-12:50	FE-1	EHS GC/DMS Ops Start
12:45-12:50	FE-2	JEMRMS RLT-BU Activation
13:50-14:10	FE-1, FE-2	Shuttle Prepack Conference *(S-band)*
14:00-16:00	CDR	Replace Heating Loop КОБ24 Replaceable Pump Panel СПН1 Pump H2
14:15-14:20	FE-2	JEMRMS RLT-BU Confirmation
14:20-14:30	FE-2	JEMRMS RLT-BU Deactivation

http://www.nasa.gov/mission_pages/station/timelines/index.html

Step 1: Identify Robotics Activity *REMLOGs*

Generated by flight controller (FC) in conjunction with console output

Pro: Embedded with assoc. telemetry

Con: Sporadic notes

Example:
SSRMS Ops

```
139:10:39:15 C&W ALARM R6F - SSRMS Base LEE VDU PFM Carrier On Video 2 Err 0 CMRC13SW03N2U 0
139:10:39:25 C&W NORM R6F - SSRMS Base LEE VDU PFM Carrier On Video 2 Err 0 CMRC13SW03N2U 0
139:10:39:45 C&W ALARM R6F - SSRMS Base LEE VDU PFM Carrier On Video 2 Err 0 CMRC13SW03N2U 0
---------------------------------------------------------------------------------------------------------------------------
139:10:39:54

 robo>>flight: we are complete with video setup. like a go to run lee and joint diags and checkout
 flight: 2ja lcc stuff?
 robo: yes
 flight: go

---------------------------------------------------------------------------------------------------------------------------
139:10:39:55 C&W NORM R6F - SSRMS Base LEE VDU PFM Carrier On Video 2 Err 0 CMRC13SW03N2U 0
139:10:40:05 C&W ALARM R6F - SSRMS Base LEE VDU PFM Carrier On Video 2 Err 0 CMRC13SW03N2U 0
139:10:40:35 C&W NORM R6F - SSRMS Base LEE VDU PFM Carrier On Video 2 Err 0 CMRC13SW03N2U 0
139:10:40:43 DSM ADV OCS>Video Routing Command Status (Acc) 4025 CMRC13SW0379U 4091
139:10:40:55 C&W ALARM R6F - SSRMS Base LEE VDU PFM Carrier On Video 2 Err 0 CMRC13SW03N2U 0
139:10:41:15 C&W NORM R6F - SSRMS Base LEE VDU PFM Carrier On Video 2 Err 0 CMRC13SW03N2U 0
139:10:41:17 DSM ADV OCS>Test Units (Acc) 4025 CMRC13SW0373U 148
139:10:41:18 DSM ADV SSRMS>Enter Diagnostics State (Acc) 4025 CMRC13SW0375U 128
139:10:41:18 DSM ADV SSRMS>Enter Diagnostics State (Com) 4025 CMRC13SW0376U 128
139:10:41:18 DSM ADV SSRMS>Execute LEU Diagnostics (Acc) 4025 CMRC13SW0378U 2057
139:10:41:18 DSM ADV SSRMS>Remove EE Inhibit (Acc) 4025 CMRC13SW037AU 1924
139:10:41:18 DSM ADV SSRMS>Remove EE Inhibit (Com) 4025 CMRC13SW037BU 1924
```

Step 1: Identify Robotics Activity *ROBO Flight Controller Logs*

Actual logs of the FC's from their time on console

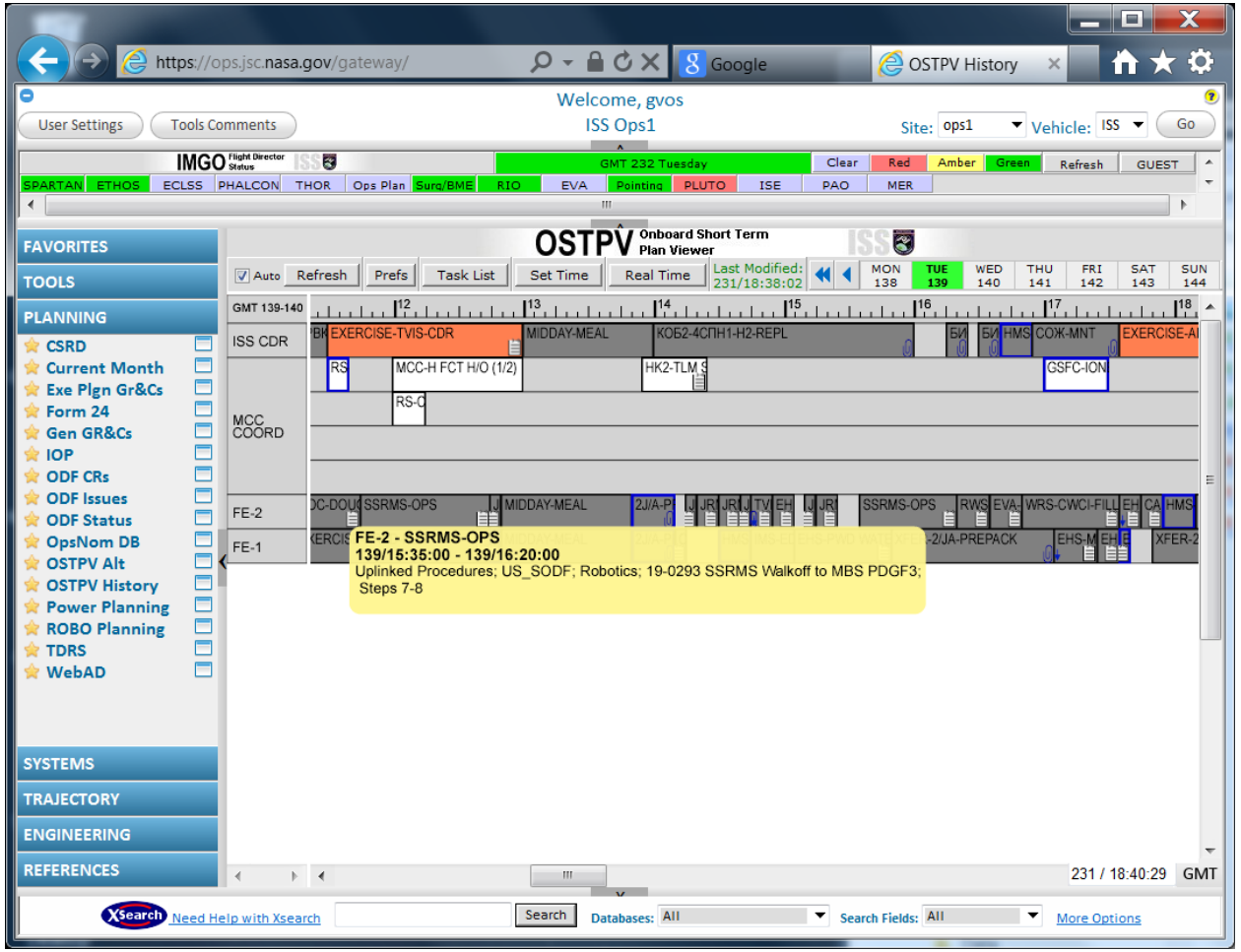
Pro: Most detailed representation of activities found outside of OSTPV

Con: Differing level of detail based on FC

GMT	Notes
139/9:00	On console for walkoff to PDGF3 and 2J A pre-launch checkout ops
9:36	Got a GO From FLIGHT to unsafe the type As and performed powerup Gave TITAN a Go for step 1 of the video note
9:38	Revised the procedure for the snare checkout with comments from the crew office
9:41	Submitted Req ID 1614 for CUP WHS
9:43	CUP CEU powered. IO enabled
9:55	WHS IFT in progress
9:59	Set location in progress
10:03	Cup RWS Backup. Got the expected DCP comm. messages
10:11	SSRMS Operational on prime
10:20	SSRMS and MBS video powerup script complete
10:34	Video setup complete. MBS Mast shows no c-curves. Got a GO for the Diags from FLIGHT
10:42	LEE B LEU diags complete. All Good
10:46	SSRMS Prime string brake diags complete. All good
10:48	SSRMS Prime string J EU diags complete. Repeated it to get all the resolver interface messages. All good
11:01	LEE B checkout on prime complete. All good
11:20	No c-curves after the LEE checkout on LEE B. Notified FLIGHT that the crew can skip step 3 in msg 293
11:39	Crew starting Msg 293. Will skip step 3

Step 1: Identify Robotics Activity *OSTPV*

- **Most accurate option.**
- **Took significant effort, permissions, and time to acquire access.**
- **Reflects actual activities.**
- **Contains links to procedures, but many links were dead.**
- **Allowed for final confirmation of crew assignments with telemetry and video.**
- **Lists activities by crew assignment historically, names**



Step 2: Obtaining Access to Robotics Measures

- Robotics Data Identification and Training:
  - Met with multiple flight controllers who educated us on the ways data was buffered and transmitted to ground and then stored for later review
  - Trained us on how to review robotic telemetry data
  - Educated us on which telemetry would be of most interest
  - Demonstrated how they review hand controller plots
  - Provided us with pre-flight training materials and rating sheets
- ISS Telemetry Data Access:
  - Required access multiple access permissions
- Video Feeds:
  - Available internally via a NASA online repository (NASA Imagery Online)
  - Contained multiple downlink channels of video, both internal and external video feeds, as well as hand held camera data
- Challenge:
  - **ISS robotic activities were not always done by the scheduled crewmember, so visual confirmation via video feed was required**

Step 3: Training for Robotics Data Use and Interpretation

- Robotic training tools as metrics of performance
- Challenge: **The rating sheets require detailed observation of a single FE including audio, but this is not present from lab video feeds, and both internal and external camera feeds are inconsistent**

Student: **IA:** **Instructor:**
Date: **Lesson:**

EVA / Payload Maneuvering

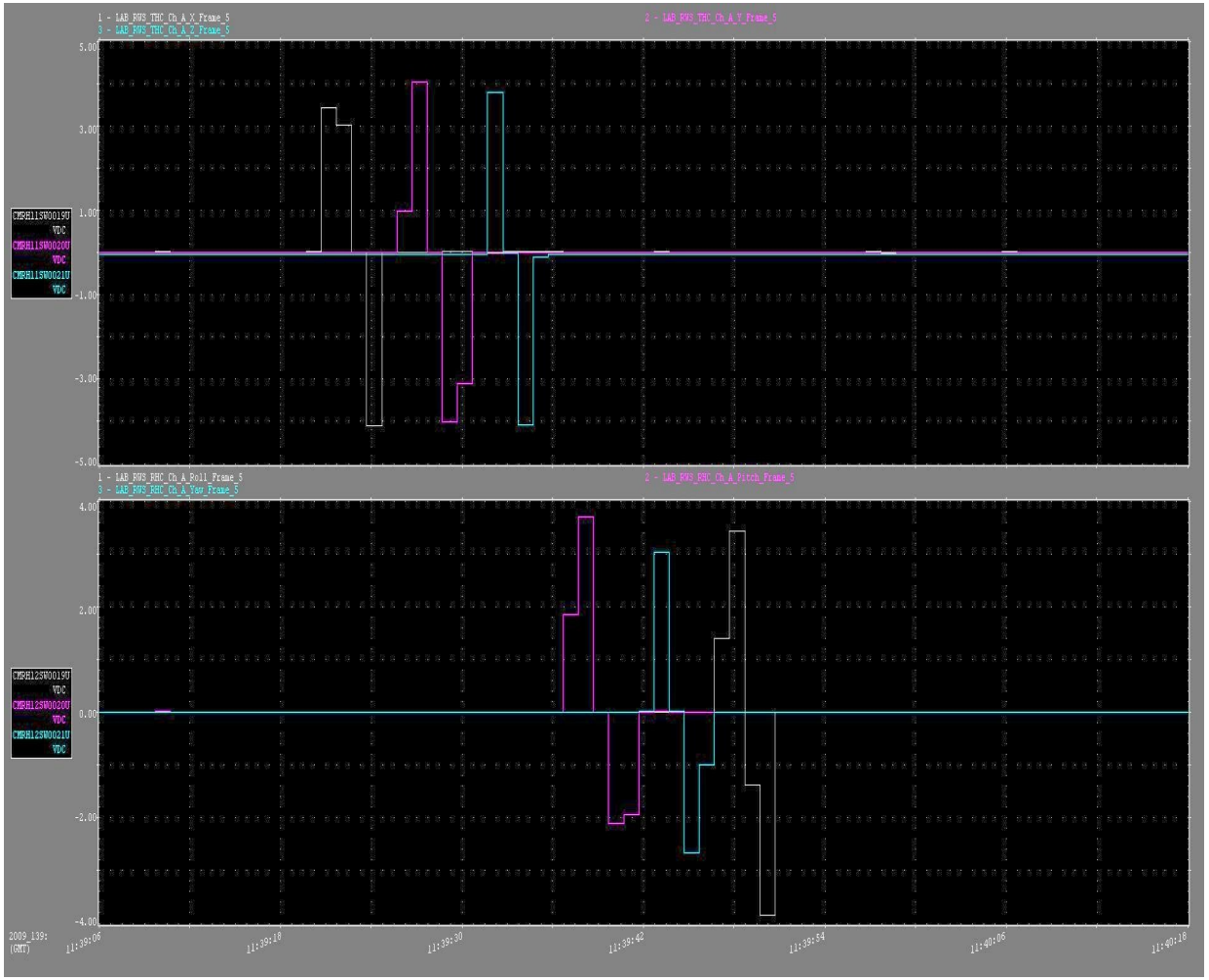
Skill Category	Wt.	1:	2	3:	4	5:	Net
Situational Awareness/ Clearance Monitoring: Structural contact; Clearance verbalization; Camera selection/adjustment for clearance monitoring; Real-time camera tracking; Scan Pattern; Recognition of unexpected signatures	3	Structural or persistent guide contact ; Does not verbalize clearance often enough; Poor camera views selected; Does not monitor elbow/entire arm; Not actively following motion; Poor scan pattern; Focuses on 1 view; Fails to recognize unexpected signatures		No structural contact; Brief guide contact (berth/unberth); Verbalizes clearance occasionally; Maintains big picture, task and clearance views; Cameras properly setup; Good real-time tracking; Acceptable scan pattern; Slow to recognize unexpected signatures		No structural or guide contact; Verbalizes clearance frequently; Uses EV crewmember for clearance help if needed; Maintains >0.6m (2') clearance; Cameras properly setup; Explains misleading views; Consistently monitors elbow/entire arm; Always actively follows motion w/ camera; Excellent scan pattern; Quickly recognizes unexpected signatures	
Efficiency: Ahead in procedure and ahead of EV crew; task completion within allowed time limit; demonstrates quick and correct decision making and execution.	3	Does not stay ahead of EV crew in procedures; Leaves EV waiting on M1; Does not achieve plan in allotted time; Poor decision making; Excessively slow and deliberate in executing procedure.		Sometimes ahead of EV crew in procedure; Accomplishes timed portion of nominal EVA task within limits; Slow to make decision on EVA emergency scenario; slow to execute procedures.		Always ahead of EV crew in procedure; Accomplishes timed portion of nominal EVA task ahead of schedule; Makes timely and correct decision during emergency scenario; Executes procedures quickly.	
Space Flight Resource Management (SFRM): Use of tools (DOUG); M2 / EV / MCC coordination and communication; M2 and EVA Briefings; Attitude	2	Underuse, misinterpretation, or over reliance on DOUG; Excessive or no coordination with M2/EV/MCC; Poor communication protocol; EVA brief does not include correct information; Negative attitude		Adequate use of DOUG; Some coordination with M2/EV/MCC; Acceptable communication; generally uses established voice protocol; Conducts long or incomplete EVA brief; Occasional positive attitude.		Appropriate use and weighting to all resources; Excellent coordination w/ M2/EV/MCC for all tasks; Effective and efficient communication; Always uses proper voice protocol; Exemplary EVA and M2 brief; Positive attitude	
EVA Maneuvering / Handcontroller Techniques: GCA interpretation; Motion control/steadiness (Ramping); Multi-axis inputs; Correct command inputs; Overall strategy (mode selection/ trajectory); joint limits and singularities; Self-collisions	2	Misinterprets EVA GCA; Jerky inputs with many starts and stops; Tendency for single-axis control; Frequently guesses/hunts for correct HC commands; Plan not thought through from beginning to end; Repeatedly encounters same arm limits; Cannot recover from singularity or self-collision		Usually interprets GCA correctly; Some cmds have rapid onset or sharp drop off; Occassional multi axis commanding; Sometimes guesses/hunts for correct HC commands; Plan requires a few major updates to reach desired position; Able to work around arm limits encountered; Recovers from singularities and self-collisions		Always interprets GCA correctly; All commands ramped smoothly in and out; At ease with multi-axis commanding; Correct and deliberate HC command inputs; Plan requires no major updates to reach desired position; Able to quickly work around arm limits encountered; Avoids singularities and self-collisions	

Step 3: Interpretation of Performance Data

Downlink telemetry for hand controllers

Cross-referenced with video feeds and time-synced for detailed data analysis

Example:
SSRMS Ops
05/19



Step 4: Access to HF, Environmental, and Medical Parameters

- We consented our test participant and secured a data use agreement for internal use of operational and medical data.
- Met with PI's for a HRP funded study and secured approval for use of their sleep research data in our test case.
- We obtained access to health and medical data, but only after some delay due to policies of "first right of publication"

Step 5: Looking for Associations

- Step 5: Assess human performance and medical/research data to identify associations
  - Assessed human performance in robotic tasks using operationally relevant ratings of performance in association with research and medical data
  - Since we only had a single test participant, and only 6 data points of robotic operation, no significant finding was expected, nor found
  - The goal was really just to get access to the relevant types and sources of data, and identify challenges to this type of investigation using both operational and medical data

Test Case Findings

Operational Findings	Recommendations
Access to Operational Data is Possible, but Time Consuming and Difficult, Requiring Collaboration	Creating relationships to leverage existing points of contacts in other directorates for access to and interpretation of operational data would be more efficient, reliable, and effective than training each individual researcher. This could be done via an exchange of time and resources between HRP and Mission Operations Directorate (MOD).
Planned Collection of Operational Data May be More Effective than Retrospective Access	Retrospective recreation of context is extremely difficult even when possible. Use of real-time rating would allow for rapid assessment of potential affecters of human performance.
Operational Procedures Are Not Maintained in a Historic Archive	Procedures on OSTPV (On-Board Short Term Plan Viewer) should be maintained through the OSTPV interface. Or, those with OSTPV access should be provided access to a file-share or SharePoint site with historic procedures, and given information on how to determine which files are associated with which tasks on a given date.
Facilitating Data Acquisition in Real-Time by Operations Personnel Requires Support and Changes to Existing Processes by the Operations Directorate	Proposed process changes (real-time assessment) need collaborative work to ensure proper design and vetting by operational experts. Recommend creation of a formal link between HRP and MOD by a Memorandum of Understanding (MOU), and creation of a joint working group.
Training Records Retention is at the Discretion of the Flight Controller or Trainer	Training data should be saved, returned to ground (if collected on ISS), and stored whenever possible.
Situation Awareness Data (e.g.,	Data from Situation Awareness tools should be stored and

Test Case Findings

Human Research Program Findings	Recommendations
Incremental Data Drops Should be Requested from PIs	Based on the need for incremental and interpretable data, NASA should require periodic delivery of interpreted data.
Accessing LSDA/LSAH Data Takes Time	The LSAH/LSDA staff needs more civil servant and contractor support, with dedicated roles. Additionally, the data request website should inform requesters that data delivery can take in excess of 12 months from the time of request (until such time as that delay is mitigated).
Consenting of Crew Takes a Lot of Time	It can be incredibly difficult to get consent from crew after the fact. The current work to consent crew to use research data for future studies (other than its original collected study) is strongly supported to continue.
Hypothesis Based Collection of Prospective Research Data May Be More Effective Than Retrospective Access	Just as with operational data, retrospective use of legacy health and medical research data involved significant hurdles of crew consent for using historic data in new ways, and consent of the original data's PIs. Just as consent of crew in new studies should include a clause allowing use of their data in future work, we should also request PIs to allow their data to be used in future studies by other NASA researchers or NASA funded PIs, given certain to be defined considerations.
Crew Data in LSAH/LSDA Lack a Standardized Unique Identifier	There is not a single ID code that can be used to track crew across studies or into the operational data realm. Such an ID system should be created.
Policies Exist for Proper Management and Handling of Data, But NASA Fails to Exercise Its Policy Based Rights	All future NRA releases should stipulate delivery of interpreted and scored data along with raw data (historic requests focused on raw data alone). Formal definitions of what is meant by interpreted or scored data also need developing and definition

Current Activity: Beyond the Test Case

- **Interviewing experts to identify:**
  - Metrics used to assess performance (e.g., time on task, distance to target) across domains
  - Focused issues for further data mining
  - Interpretation of consequences related to performance outcomes
- **Experts will include operational personnel from several demographics:**
  - Crew
  - Flight controllers
  - Trainers
  - Flight surgeons
- **How interviewees will assist us:**
  1. Target areas to focus our attention (scope)
  2. Identify optimal points of contact for each domain
  3. Identify metrics and/or issues they are

Identified Operational Domains
• Training • EVA • Robotics & Automation • Piloting • Science Execution • Health & Medical • Station Keeping • Maintenance • Habitability

Questions ?

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